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Innovative Technology for Sustainable Agriculture Development

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Dr. A.K. Singh

Foreword

Spectacular progress has been achieved in agricultural production in the country during the last five decades which has been globally recognized. Now we have huge buffer stocks of food grains and other agro-commodities. The dairy-sector has witnessed a white revolution. In Inland Fisheries, the country has registered an unprecedented compound growth rate of 10 per cent bringing in blue revolution. The growth in poultry production and horticulture sector is also appreciable.

However, future projecting of growing population, urbanisation and climate change, indicate towards bringing in a robust sustainable system. Among all the factors, unsustainable production practices play a major role and also responsible for poor production and productivity. The meaning of sustainability for agriculture and rural development contains issues of environment, economy and society. The sustainability includes to satisfy changing human needs like food, feed, fiber, etc., enhance environmental quality and the resource base, sustain the economic viability of agriculture and enhance the quality of life for farmers, farm workers, and society as a whole.

In this context the book entitled: "Innovative Technology for Sustainable Agricultural Development" edited by Dr. Sarju Narain and Sudhir Kumar Rawat would prove as a source of sustainable production practices. I feel it is a valuable collection covering wide range of information and technologies and thus, would be useful for extension personnel, researchers, student and also for those engaged in the development of agriculture and rural-upliftment at various levels.

I compliment and congratulate the editors, chapter contributors for their efforts and hard work in bringing out a very useful publication at an appropriate time.

A.K. Singh

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Chapter 29

Beekeeping for Poverty Alleviation and Livelihood Security in Chhattisgarh, India

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ABSTRACT

India is an agricultural country and majority of its population lives in the rural areas, whose livelihood either directly or indirectly rely on this sectors. After independence India launched a massive programme of rapid industrialization. Though, India has achieved self-sufficiency in food grains and now is recognized as one among world's largest grain producers. Beekeeping plays an important role in the sustainable agriculture as it contributes significantly as an allied industry. Apiculture provides supplementary and sometimes key source of income, especially to the marginal/small farmers. Bee keeping is a non-land based income generating enterprises, fast emerging as essential component of present time strategies for integrated rural development and off-farm employment for sustainable livelihoods. Bee fauna is affected by indiscriminate application of pesticides, diseases and enemies, low price of products, marketing, climate change, radiation, suitable bee flora etc. which were major limiting factors in the prospects of beekeeping. It is necessary to find out the suitable bee flora available and required in the locality to manage and propagate the plant species with abundant nectar and/or pollen to facilitate efficient honey flow period for commercial production. Government should possess serious concern to the problems faced by bee

keepers and promote farmers for honey bee farming, so that they can fetch higher return from apiculture besides ecological and environmental services.

Keywords: *Beekeeping, Bee flora, Climate change, Ecological and environmental services, Livelihoods.*

Introduction

Honey bees are one of the most well-known, popular and economically beneficial insects. It benefited the society by producing honey with other produces and by pollination services which ultimately increases the production. For thousands of years, man has plundered honey bee colonies to get honey, bee larvae and beeswax. In recent decades, bee plundering has given way to bee management. Now, honey bees are commonly kept in artificial hives throughout the world, and a large and sophisticated beekeeping industry provides valuable honey, beeswax and pollination services. A large section of the industry, well represented in Punjab and Bihar states, they are devoted to mass-producing queens and bees for sale to other beekeepers. Although many people make a living from bees, most beekeepers are hobbyists who have only a few hives and who simply enjoy working with these fascinating insects.

Honeybee and plant have a special symbiotic relationship. Bee flora is important for establishing beekeeping industry. The awareness to maintain the existing bee flora and multiplication of plant species is important for its sustainability. Plant types and their flowering periods and duration differ from place to place due to variation in topography, climate and other cultural and farming practices. The value of flora in bee keeping has been observed in many parts of the world. For instance, the directory of world honey resources of Hindu Kush-Himalayan region (Verma 1990; Partap 1997) and bee flora of India (Kaur and Sihag 1994) are some existing examples of such efforts.

Beekeeping is farming related and forest based activity. Bees obtain nectar, pollen or both from flowers which is the necessity for its survival. Tribal communities living in and around forest improve their social and economical livelihood by collecting and selling honey and other products of honey bees. Most of the population live in rural India and depend on agriculture, therefore, in the second phase of developmental programmes more emphasis was given to agriculture. Huge investments were made in agricultural research and extension in order to boost up the crop production and India now became self-sufficient in food production. Special efforts were also made to develop various agro based industries like dairy, poultry, fish farming, sericulture and beekeeping. Out of these, beekeeping industry received inadequate attention resulting in its stagnation. The extensive knowledge on type, density and quality of bee flora are key points for successful beekeeping. Every region has its own honey flow and floral dearth periods of short and long duration. Such knowledge on bee flora helps in the management of bee colonies during such period effectively. By bringing all the available bee species and their rapid multiplication, honey and beeswax production can be increased manifold and crop production can also be significantly increased. A revolution in Beekeeping (golden revolution) have launched in India, which is complementary to "Mission Hunger Free India", therefore, emphasis should be more on this aspects with scientific and technical approach to generate income for the upliftment of socio-economic value but also concerns the ecological and environmental stability.

Bee Resources and Beekeeping

About 5 crore bee colonies, mostly *Apis mellifera*, are maintained all over the world. UNCTAD report (1986) showed that world production of honey was estimated at about 10 lakh M.tons. There are 15 countries in the world which account for the 90 per cent of the global honey production. Among the asian countries, China alone producing about 1.6 lakh M tons of honey and nearly 12800 M tons of beeswax as against 43400 M tons of world production. Beside these, China also produces 1000 M.tons of pollen and 800 M.tons of royal jelly and is the biggest exporter of honey, beeswax and other bee products. China like India has indigenous *A. cerana* bee colonies and like India has introduced western *A. mellifera* bees. There are about 70 lakh *A. mellifera* bee colonies and 30 lakh *A. cerana* bee colonies in China and they have a plan to increase this number to 5 crore during next few decades. India has nearly 10 lakh *A. cerana* and 2 lakh *A. mellifera* bee colonies (UNCTAD 1986). By adopting a strategy to increase the colony number along with the productive efficiency of bee colonies, India can also become a large producer and exporter of bee-products, besides utilizing large number of bee colonies for pollination services.

Asia has a poorer bee fauna as compared with other biogeographical regions (Michener 1979) and lower diversity than the Neotropics, but in terms of abundance of the social bees are the most numerous in the pollinator spectrum (Roubik *et al.*, 2005). India is abundant in nectar and pollen resources. However, systematic documentation for each region and state is not available. Out of the total, about 150 million hectares of cropland, nectar and pollen crops are grown in one third of the area. The loss of these pollination services would have adverse consequences for food production and for the maintenance of biodiversity (Allen-wardell *et al.*, 1998; Klein *et al.*, 2006). Studies in south East Asia reveal that about 32 per cent of flower visiting insects in Sumatra are APIs bees (Momose *et al.*, 1998). In medium elevation wet-evergreen forest of Western Ghats, APIs bees contributed to the pollination of 18 per cent of 86 species of trees, and 22 per cent of under storey shrubs (Devy and Davidar 2003 and 2006).

India is fortunate to have all four major honeybee species *viz.*, *A. cerana*, *A. dorsata*, *A. florea* and *A. mellifera* (an introduced one). They have become an integral part of Indian agriculture and rural economy both as pollinators and honey producers. Nowadays, the products of the honey bee, *A. mellifera* L., are of great concern in many fields, e.g. nutritional and pharmaceutical industries. Honeybees provide honey and other hive products like royal jelly, bee venom, bee pollen and propolis, which have great economic value. Yet, beekeepers in India in general depend on beekeeping only for producing honey. To increase the profits from the apiary units, the beekeepers are required to exploit bees for the productions of these hive products.

Honey Bee Biology

Honey bees, like ants, termites and some wasps, are social insects. They live together in groups, cooperate in foraging tasks and the care of young, and have different types, or "castes," of individuals. There are three castes of honeybees (Mathur and Upadhyay 1998):

Workers

A colony may have 2,000-60,000 workers. Reproductively under developed female that does all the work of the colony.

Queen

A fully fertile female specialized for producing eggs. When a queen dies or is lost, workers select a few young worker larvae and feed them a special food called royal jelly. These special larvae develop into queens. The only difference between workers and queens is the quality of the larval diet. There is usually only one queen per colony. The queen also af-fects the colony by producing chemicals called "pheromones" that regulate the behavior of other bees.

Drones

(Male bees): A colony may have 0-500 drones during spring and summer. Drones fly from the hive and mate in the air with queens from other colonies.

The queen lays all her eggs in hexagonal beeswax cells built by workers. Developing young honey bees (called "brood") go through four stages: the egg, larva, pupa and adult.

Table 29.1: Periods of Development of different Castes of *Apis indica* (Chand and Singh 2002)

Adult	Egg	Grub	Pupa	Total
Queen	3 days	5 days	7-8 days	15-16 days
Worker	3 days	4-5 days	11-12 days	18-20 days
Drone	3 days	5-7 days	13-14 days	21-24 days

Honeybee Fauna in Chhattisgarh

There are mainly three bee species found in Chhattisgarh state. Among these Indian honey bee (*Apis indica*), rock bee (*Apis dorsata*) and little bee (*Apis florea*) are commonly found in three agro-climatic zones of the state. The domestication of Indian honey bee is common in north zone *i.e.* Surguja whereas harvesting of honey from rock bee by bee hunter is very common. The brief details are as follows-

(a) Indian Bee

Very commonly found everywhere in India and also in Chhattisgarh and can easily domesticate. It is about 18 mm in length and like to live in dark places, therefore,

the ground, hollowed places in walls, unused boxes etc. On an average 3-4 kg honey is found from a colony annually.

(b) Rock Bee

It is found in all parts of India and big in size to another bee measuring about 20 mm in length. It is very good honey gatherer and builds a single huge comb in the face of the rock, on branches of big trees and sometimes on walls and buildings. The comb is always built in open places that are why the bee could not be domesticated until now. This bee is capable of storing 20-40 kg honey.

(c) Little Bee

This is smaller than the Indian bee and found everywhere in India. It built single comb which is very small and only 250 gm honeys is obtained at a time. The honey produced by them is the sweetest one.

Scope and Potential of Apiculture in Chhattisgarh

The State Chhattisgarh having three agro-climatic zones *viz.* Chhattisgarh plains, Baster plateau and North hills representing 16, 06 and 05 districts, respectively with varying flora and fauna. The state is dominated tribal people predominately in Baster plateau and in North hills. Earlier the Khadi and Village Industries Commission (KVIC) primarily identified potential area for beekeeping in undivided Madhya Pradesh and started beekeeping work during 1947 from Surguja with the introduction of Indian honey bee for domestication. The agro-climatic zone wise status (Shaw *et al.*, 2008) of beekeeping is started as under:

(a) Northern Hills Region

The northern hill region includes five districts *viz.* Surguja, Jashpur, Koria, Balrampur and Surajpur. Surguja division in Chhattisgarh is very rich in natural vegetation and biological wealth (Sinha *et al.*, 2014 and 2015; Yadav *et al.*, 2015). The beekeeping activity was started during the year 1947 by the efforts of KVIC. The domestication of Indian honey bee is common but in unrecognized manner however, the harvesting of honey from rock bee is also practiced by the bee hunter following the method of burning of the colony. Efforts are being made by state forest department by imparting training to bee hunter about the scientific harvesting of honey from rock honey bee by inviting the experts from CBR and TI. Pune during the year 1995-96.

(b) Bastar Plateau

The Bastar plateau is in the southern region of the state, having six districts in its jurisdiction. The bio-diversity of plateau is well known feature and about 47 per cent area comes under forest. The mono-cropping nature of the region is the main constraints for promoting the beekeeping activities. The domestication of Indian honey bee is not common but in some pocket like in Kondagaon area some beekeepers are engaged in domestication of Indian honey bee. But the honey harvesting from rock bee is very common without using scientific harvesting method which is major threat to rock bee population in the region.

(c) Chhattisgarh Plains

The plain region includes 16 districts, where crop diversification programme is being intensified by the state government. The domestication of Indian honey bee is done in the scattered area and it comprised mainly in districts of Durg, Bilaspur and Janjgir-Champa. The efforts are being made to domesticate it by providing 1000-1500 bee hives to beekeepers of Bilaspur district under Shum Vikas Yojna Programme (SVYP) of state forest department.

Potentiality of Apiculture Enterprise

- The state having favourable climatic condition along with the rich floral diversity.
- There are so many nectar and pollen producing plants throughout the state.
- No need of land in beekeeping and this is not high technological matter.
- An illiterate person can start this enterprise by taking training on beekeeping.
- Honey is not perishable good; it remains fresh till a year in normal condition, so farmers/producers can easily store it.
- Honey helps to prevent malnutrition and have medicinal values.
- Beekeeping may be complementary or substitute of reduction of poverty.
- Variable cost is very low; therefore, it is a profitable enterprise.
- Source of extra income, which helps to improve living standard of rural people.
- Employment creation by extending the beekeeping in rural areas.
- It is an ecological and environment friendly enterprise.

Honey Bee Flora in Chhattisgarh

Honey bees collect nectar and pollen from flowering plants. Nectar is a sweet secretion from the floral and extra-floral nectarines of flowers and is the raw material for honey. Pollen is protein rich food for the bees. The plants that yield nectar and pollen are collectively called bee flora, bee pasturage or bee forage. The period when a good number of plants providing nectar and pollen are available to bees is called honey flow period. If the nectar yield is copious from a good number of plants of a particular species, it is called major honey flow period. When the amount of nectar to be collected is small, it is called minor honey flow period (Srivastava and Dhaliwal 2013).

Honey-Non-Wood Forest Product (NWFP)

Forest is the heart of the environment, though silent, it provides an everlasting and priceless service to this universe. Environment supplies every need of the forest and reproduction is very essential in maintaining this chain. The reproduction of plants helps to maintain the equilibrium of the environment and bees help this process by pollinating the flowers. In the global efforts to conserve forest bio-diversity, non-

Table 29.2: Essential Bee Flora for Betterment of Honey Production in North Zone of Chhattisgarh (Painkra *et al.*, 2015)

Common Name	*Scientific Name*	*Family*	*Blooming Period*	*Source*
Brinjal	*Solanum melongena* L.	Solanaceae	Round year	N+P
Chilly	*Capsicum annum*	Solanaceae	–do–	N
Shimla mirch	*Capsicum annum* L.	Solanaceae	–do–	N
Tomato	*Lycopersicon esculentum*	Solanaceae	–do–	P
Onion	*Allium cepa* L.	Liliaceae	Feb-May	N+P
Radish	*Raphanus sativus*	Cruciferae	Oct-April	N+P
Sesamum	*Sesamium oriental* L.	Pedaliaceae	August-Oct	N+P
Sunflower	*Helianthus annus* L.	Astraceae	Round year	P
Niger	*Guizotia abyssinica*	Compositae	Oct-Mar	N+P
Mustard	*Brassica campestris*	Cruciferae	–do–	N+P
Buckwheat	*Fagopyrum esculentum*	Polgonaceae	Sep-Feb.	N+P
Arhar	*Cajanus cajan*	Leguminaceae	Sep-Apr.	N+P
Moong	*Vigna radiata*	–do–	Aug-Oct	N
Gram	*Cicer arietinum*	–do–	Dec-Feb	P
Lentil	*Lens esculenta* L.	–do–	–do–	P
Lathyrus	*Lathyrus sativus*	Leguminaceae	Dec-Feb	N+P
Pea	*Pisum sativum*	Leguminaceae	Nov-Feb	N+P
Maize	*Zea mays* L.	Graminae	Round year	P
Corinder	*Coriandrum sativum*	Umbelliferae	Nov-Feb.	N+P
Methi	*Trigonella foenumgraecum*	Leguminaceae	–do–	N+P
Bhindi	*Abelmoschus esculentus*	Malvaceae	Sep-Aug	N+P
Carrot	*Dacus carota* L.	Umbelliferae	Oct-Mar	N+P
Turnip	*Brassica rapa* L.	Cruciferae	–do–	N+P
Sakarkand	*Ipomoea batatas*	Convolvulaceae	Sep-Nov	N+P
Rice	*Oryza sativa*	Graminae	Sep-Dec	P
Bottle gourd	*Lagenaria siceraria*	Cucurbitaceae	Round year	N+P
Bitter gourd	*Momordica charantia*	Cucurbitaceae	Round year	N+P
Pumpkin	*Lagenaria vulgaris*	Cucurbitaceae	Aug-Jan	P
Cucumber	*Cucumis sativus*	Cucurbitaceae	Round year	N+P
Cabbage	*Brassica oleracea* L.	Cruciferae	Oct-Mar	P
Cauliflower	*B.O. var. botrytis*	–do–	–do–	P
Knol khol	*B. caulorapa* L.	–do–	–do–	P
		Fruits Species and Forest Trees		
Guava	*Psidium guajava* L.	Myrtaceae	Apr-May Jun-Aug	N+P
Papaya	*Carica papaya* L.	Caricaceae	Round year	N
Mango	*Mangifera indica* L.	Anacardiaceae	Mar-Apr	N

Table 28.2—Contd...

Common Name	Scientific Name	Family	Blooming Period	Source
Citrus	*Citrus limon* L.	Rutaceae	Nov-feb	N+P
Litchi	*Litchi chinensis* Sonn.	Sapindaceae	Mar-Apr	N+P
Banana	*Musa paradisiacal*	Musaceae	Round Year	N+P
Ber	*Zizyphus jujuba* Lam.	Rhamnaceae	Sep-Oct	N
Tamarind	*Tamarindus indica*	Leguminoceae	May-Jul	N+P
Jamun	*Syzygium cumini* L.	Myrtaceae	Apr-May	N+P
Moringa	*Moringa oleifera*	Moringaceae	Nov-May	N
Neem	*Azadirachta indica* Juss.	Meliaceae	April	N
Semal	*Bombax ceiba* L.	Bombacaceae	Dec-Mar	N
Shisham	*Dalbergia sissoo*	Papilionaceae	Mar-Apr	N+P
Kachnar	*Bauhinia variegata*	Caesalpiniaceae	Sep-Nov	N+P
Kapok	*Ceiba pentandra*	Bombacaceae	Mar-Apr	N+P
Gulmohar	*Delonix regia*	Bignoniaceae	Apr-June	P
Arjun	*Terminalia arjuna* Rox.	Combretaceae	Apr-May	N+P
Bamboo	*Dendrocalamus strictusness*	Poaceae	Apr-May	N+P
Bottlebrush	*Callistemon lanceolatus*	Myrtaceae	Mar-Apr	N+P
Dhwai	*Woodfordia fruticosa*	Lythraceae	Oct-Apr	N
Coffee	*Coffea arabica*	Rubiaceae	Apr-May	N
Sal	*Sorea robusta*	Dipterocarpaceae	Apr-May	N
		Ornamental plants		
Dahlia	*Dahlia Spp.*	Astraceae	Nov-May	N+P
Marigold	*Tagetes erecta*	Compositae	Oct-May	N+P
Dianthus	*Dianthus caryophyllus*	Caryophllaceae	Jan-Apr	N
Balsum	*Impatiens balsamina* L.	Balsaminaceae	Jan-Apr	N
Aster	*Callistephus chinensis*	Compositae	Dec-Mar	N
Calendula	*Calendula officinalis*	Astraceae	Jan-May	N
Pitunia	*Petunia exillaries*	Solanaceae	Jan-Apr	P
Nastertium	*Nastertium tropaeolummajus*	Tropaeolaceae	Jan-May	N+P
Popy	*Papaverdubium* L.	Paparveraceae	Jan-Apr	P
Hollyhock	*Hollyhock althacrosia*	Malvaceae	Jan-Apr	P
Ginia	*Zinnea elegans*	Balsaminacena	Dec-Apr	P
Phlox	*Phlox drummondii*	Polimoniaceae	Jan-Apr	N
Barbins	*Verbena hybrida*	Verbenaceae	Jan-Apr	N
Portulaca	*Portulaca oleracea*	Oleraceae	Jan-Mar	P
Cosmos	*Cosmos sulphurous* Cas.	Compositae	Dec-Mar	N+P
Cock's comb	*Celosia plumosa* L.	Amaranthaceae	Oct-Feb	N
Cornflower	*Centaurea cyanii* L.	Astraceae	Dec-May	P

Contd...

Table 28.2—Contd...

Common Name	Scientific Name	Family	Blooming Period	Source
		Weed flora		
Wild sunhemp	*Crotolaria verrucosa*	Leguminaceae	Sep-Feb	N+P
Water frewotel	*Bidens pilosa*	Asteraceae	Round year	N+P
Bhanahi	*Ageratum conyzoides* L.	Asteraceae	Round year	P
		Medicinal Plants		
Adusa	*Adhatoda vasica*	Acanthaceae	Round Year	N
Aswagandha	*Withnia somnifera*	Solanaceae	Oct-March	N+P
Bhringraj	*Eclipta alba*	Asteraceae	Round Year	N+P
Karanj	*Pongamia pinnata*	Fabaceae	March April	N
Justicia	*Justicia gendarusa*	Acanthaceae	March-April	N

Note: N: Nectar; P: Pollen.

wood forest products (NWFPs) offer abundant opportunities, as the extractive reserve of such products provide ecologically sustainable economic security. Non-wood tre products are used by people every day of their lives for their own need. Multipurpo trees play an important role to fulfill all needs as tangible and intangible benefi (Jhariya et al., 2015). Non-wood forest products (NWFPs) include a broad range edible, medicinal, decorative and handicraft goods harvested from woodlands.

The status of NWFPs has improved due to the realization that they contribu substantially to the rural economy and livelihoods. Honey is a natural non-woo resource, with a multidirectional value to both the honeybee and man. It is a produ of plant-insect interaction and unlike other NWFPs, its production and extractio does not adversely change the species structure, composition and regeneration forest ecosystems. In Indian context, more than 100 million people live in and arou forest and mainly rely on the gathering and trading of NWFPs (Sinha and Ray 2002). Out of the total production of honey in India, more than 50 per cent come fro natural forests, which signify honey as one of the main NWFPs in India. Unlike oth NWFPs, honey extraction has the least negative impact on forest ecosystem Moreover, the tribal people follow traditional management practices for maintaini sustainable extraction and such a native knowledge system lays the foundation f appropriate technology development in refining and improving the manageme practices. Tribal communities and other forest dependent people prefer to genera much of their livelihoods from forests because it is a viable option, and also play important role in the extraction of honey. Hence, strategies for production, extracti and sustainable management of honey are to be modernized and imparted amo the forest dependent people.

Role of Agro-forestry, Social-forestry and Farm-forestry Apiculture

India has rich and varied vegetation dynamics (nearly possess 45,000 species plants). Though, most plants in an ecosystem produce nectar and pollen, all of th

are not beneficial to bees, and commercial exploitation of bee flora for honey production is considerably very less. Economic development in different regions has often been accompanied by a decline in biodiversity. Pollinating insects play a key role in forest and agro-ecosystem. Honeybee and plant have a special symbiotic relationship. Bee flora is important for establishing bee keeping industry. The awareness to maintain the existing bee flora and multiplication of plant species is important for its sustainability. Plant types, their flowering time and duration vary from place to place due to changes in topography, climate and other cultural and farming practices. Every region has its own honey flow and floral dearth periods. Such knowledge on bee flora helps in the effective management of bee colonies during such period.

Agro-forestry system is land management practice to cultivate woody perennial and agricultural crops on the same piece of land in temporal and spatial arrangement with sustainable production of crops and ecological and socioeconomic conditions. It is an ecologically sound and sustainable land use option alternative to the prevalent subsistence farming patterns for conservation and development. Agro-forestry is also providing livelihood opportunities through apiculture, lac and sericulture (Dhyani 2012). Agro-forestry has substantial potential to provide employment to rural and urban population through production, industrial application and value addition ventures, enhances ecosystem services that sustain and contribute to the wellbeing of human society through carbon sequestration process, prevention of deforestation, biodiversity conservation, soil and water conservation and protective functions (Jhariya *et al.*, 2011; Jhariya *et al.*, 2013; Jhariya and Raj 2014; Jhariya *et al.*, 2015). These systems can improve the livelihoods of smallholder farmers as by providing various production services, these practices may use small area of the farming land but support to improve biodiversity, habitat and harboring birds and beneficial insects like honeybees. NWFPs and their related activities provide a platform for their livelihood during lean seasons when possibilities are limited. Therefore, under the agro-forestry systems, trees can contribute nesting sites, protective cover against predators, access to breeding territory and access to food sources in all seasons and encourage beneficial species such as pollinators.

Viability of beekeeping industry depends on the density, distribution and composition of bee flora. A long-term measure to develop beekeeping is to introduce bee plants of economic utility. This can be achieved through afforestation programmes with inclusion of agro-forestry, social forestry, farm forestry, road-side avenues; canal-side avenues plantation etc. can be best practices for fulfil the objectives. If these annuals and perennial plants have staggering flowering periods continuity of bee forage and development of beekeeping industry can be assured. This is the interest of all, the beekeeping sector, the agriculture and the forestry. More emphasis is now given on agro-forestry, farm-forestry, roadside forestry, canal-side forestry, social forestry etc. All these programmes can have mixed plant species useful for fuel, food, fodder, shelter, medicines etc. and also useful to bees during their flowering. The multi purpose tree species which flowers in different months and provide nectar and pollen to honeybee continuously. However, attention must be given to maintain the existing bee flora, introduction of multipurpose plant and its multiplication in order to make it sustainable.

Impact of Honey Bees in Agricultural Production

Bees and most flowering plants have developed a complex interdependence during millions of years. Nearly 80 per cent of flowering plants are entomophilies and it is estimated that half of the tropical plants pollinated by bees. Many food crops, barring cereals are entomophilous in nature and rely on insects for pollination. Roughly 73 per cent of the world's cultivated crops are pollinated by bees, 19 per cent by flies, 6.5 per cent by bats, 5 per cent each by both wasps and beetles, 4 per cent each by birds, and butterflies and moths (Abrol 2009). In India, 90 per cent of the pollination of crops grown across 50 million hectares is done by bees (Singh *et al.*, 1989). Pollinators such as bees, birds and bats affect 35 per cent of the world's crop production, increasing outputs of 87 of the leading food crops globally (FAO 2009). The total economic value of crop pollination worldwide has been estimated at €156 billion annually (Gallai *et al.*, 2009). The area covered by pollinator-dependent crops has increased by more than 300 per cent during the past 50 years (Aizen and Harder 2009).

Influence of Bee Pollination on Crops

Bee visits plants for its food, nectar and pollen. This floral fidelity of bees is due to their preference for nectars having sugar contents and pollens with higher nutritive values. Honeybees are best known for the honey they produce, whereas the principal economic role of honeybees in nature is to pollinate various flowering plants and ensure seed set in quantity and quality. Both flowering plants and honeybees are interdependent for their biology and life cycle. Flowering plants offer nectar and pollen to honeybees and it reciprocates their obligation by bringing about pollination, maintaining genetic diversity and succession.

Table 29.3: Crops Benefitted by Honeybee Pollination (Srinivasan 2010)

Fruits and Nuts	*Vegetable*	*Oil-seed Crops*	*Forage Seed Crops*
Almond	Cabbage	Niger	Lucarne
Apricot	Cauliflower	Mustard	Clover
Apple	Carrot	Safflower	
Peach	Coriander	Gingelly	
Citrus	Cucumber	Sunflower	
Litchi	Onion	Rape seed	
Strawberry	Radish		
	Turnip		
	Pumpkin		

Role of Apiculturre in Livelihoods and Poverty Alleviation

Apiculture is one of the most widely spread agricultural sub-sectors making substantial contribution to household livelihoods and food security. In India, there is a great prospect of beekeeping on the basis of the socio-economic context and some special features of the beekeeping enterprise. It will be a great source of employment creation for the rural people to reduce the poverty. When apiculture forms part of

Scanned by CamScanner

Table 29.4: Impact of Honey Bee Visitation on different Crops

Descriptions of Pollinated Crops	Source
The highest flower heads (45.67) on niger received cacambe 10 per cent (Cacambe is the byproduct of sugarcane processing) which recorded 10.51 and 11.44 per cent increased over open pollination with water spray (44.00) and crop caged without bees (43.67) and the lowest number of flower heads were in crop caged without bees (43.67)	Dhurve (2005)
Canola rapeseed (*Brassica napus*) with more number of pods developed in treatments plants caged with honeybees (81.00) and lowest in plants caged without honeybees (52.00)	Munawar *et al.* (2005)
The individual fruit weight of cucumber significantly increased due to the bee pollination	Sarwar *et al.* (2008)
The highest seed yield was found in bee pollination with *Apis cerana* (40.07g) followed by open pollination (37.95g) and the lowest in pollination without insects (11.37g) in niger crop	Pastagia and Patel (2008)
Maximum chaffy seeds were 87.21 per cent under control treatment. While sterility per cent reduced to 33.22 and 25.54 per cent in crop pollinated with *A. mellifera* and freely pollinated with all pollinators on niger crop	Marabi (2003)
Maximum filled seeds capitulum⁻¹ (40.24) in flower exposed to all insect pollinators followed by pollinated by *A. mellifera* (36.72) and *A. indica* (34.94) and lowest was (15.06) in self pollinated crop (control) on niger crop	Choudhary *et al.* (2002)
Highest test seed weight in one frame *A. florea* colony (7.16g) followed by four frame *A. cerana* colony (6.00g), two framed *A. mellifera* colony (6.20g) and lowest in open pollination (5.5g) on onion crop	Mupade *et al.* (2009)
The higher seed yield of sunflower (849 kg ha⁻¹) in intercropping system of sunflower + niger and lowest was in sole crop of sunflower (747 kg ha⁻¹) indicating the role of pollinators in both cross pollinated crops	Gaddanakeri *et al.* (2002)
Highest oil content was in hand + insect pollination (36.30 per cent) in sunflower followed by open to all insect pollination (32.43 per cent)	Kumar *et al.* (2002)

people's livelihood strategies there are various possible outcomes, which include income and material goods, but also non-material outcomes such as well-being and contentment. Apiculture has contributed towards rural livelihoods in both subsistence and commercial uses such as food, medicine and pollination services.

Table 29.5: Increased in Yield Due to Bee Pollination (Srinivasan 2010)

Crop	Botanical Name	Per cent Yield Increase	
Onion	*Allium cepa*	93	
Mustard	*Brassica sp.*	43	
Cotton	*Gossium sp.*	19	
Sunflower	*Helianthus annus*	48	
Lucerne	*Medicago sativa*	112	
Apple	*Purus malus*	44	
Per cent Increases in yield due to bee pollination (Mohapatra *et al.*, 2010)			
Cotton	18	Niger	33
Coconut	40	Safflower	84
Gourd crops	20	Sesamum	15
Litchi	20	Sunflower	70
Mustard	55		

Besides selling honey and other bee products (such as beeswax, pollen, royal jelly, propolis, bee venom, or queens) beekeepers can also provide pollination services and generates income and can create livelihoods for several sectors within a society. Honey is also prized as a valuable medicine (Shuaib *et al.*, 2009). Beeswax is also a economic product from beekeeping, although in some places its value is not appreciated. Industrialized countries are net importers of beeswax and the supply comes from developing countries. The beekeepers and other people in a community can create further assets by using honey and beeswax to make secondary products, such as candles, beauty creams etc. Selling a secondary product brings a far better return for the producer than direct selling of raw materials.

Another crucial livelihood outcome is where, through strengthening people's livelihoods, beekeeping has managed to help a family become less vulnerable to risk, food security, strengthening their ability to look into the future, respond to changing circumstances, surmount challenges and diversified livelihood pattern/activity. In addition to their financial value, honey and beeswax have many cultural and religious values. Beekeepers are generally respected for their craft. All of these aspects are livelihood outcomes from the activity of beekeeping.

Apiculture is now being promoted by the government to support livelihoods through income generation for villagers. It is currently not widely practiced in the country but it has the potential to increased households income. Beekeeping requires very little capital for start-up; little land; less labour; and can easily be practiced by men, women, youth and people with disabilities alike. This means that beekeeping provides an opportunity for many different members of the community to use available

natural resources to support their livelihoods (UBPB 2005). Beekeeping does not compete with other enterprises for resources sharing as the bees use nectar and pollen grains of plants. Marketing facilities, capacity buildings of bee keepers, timely loan facilities, safer application of pesticides, plantation of floral plants, development of floral calendar etc. are key activities for development of apiculture.

Importance of Honey for Human

- Honey as food
- Exercise and athletic performance
- Source of antioxidants
- Digestion and absorption
- Children nutrition
- Medicinal values

Constrains in Beekeeping

Constraints facing the apiculture sector may be broadly categorized as under the biological and technical constraints (Poornima 2013). The biological constraints may includes the introduction of exotic species and races of honeybees, bee diseases, predators and parasites, the loss of indigenous species and habitat diversity, and problems arising because of pesticides use, whereas the technical constraints facing beekeepers in developing countries concern lack of knowledge of appropriate methods for managing tropical bee races and species, lack of appropriately skilled trainers, materials and training possibilities, and lack of dissemination of new research information, especially as described above, relating to disease control.

Threats to Beekeeping

- Deforestation
- Indiscriminate use of insecticides, pesticides, weedicides etc.
- Wild fires
- Mono-culture
- Weather condition
- Air and water pollution
- Climate change and global warming
- Uneven distribution of rainfall
- Steady decline of trained and extension workers.

Impact of Climate Change on Honeybee

Nowadays, there has been a great concern about declines in both wild and domesticated pollinators, especially honeybees. Climate change and global warming an emerging phenomenon, with a potential to affect every component of agricultural and other ecosystems, is reported to influence bees at various magnitudes including their pollination efficiency. Bees of the genus *Apis* are distributed throughout the

world in highly diverse climates and currently, there are only seven recognized speci of honey bees with a total of 44 sub-species, though historically, from 6-11 speci have been recognized (Engel 1999). The distribution of these species is highly uneve Among them, *Apis mellifera*, with its origin in Africa, has been introduced to differe continents while the other species have remained in Asia, which is the most likely b birth place of the *Apis* genus (Arias and Sheppard 2006). In case of *A. cerana*, fo subspecies are recognized, although there may be several more because of its wi range of geographical distribution while the genetic diversity of *A. mellifera* has bee organized into 24 sub-species (Verma 1992). This pattern of development of ecotyp signifies the impact of regional climate and geographic conditions on the evoluti and in turn their inherent ability to adapt to local environments.

Being ectothermic, the temperature of their surroundings determines the activi of bees (Reddy *et al.*, 2012b) and hence climate change, characterized by raisi temperatures, could drastically impact their biology, behavior and range distribution. Indirectly, climate change affects bees through their floral resources ar natural enemies. Differential response of insects and plants to changed temperatu could create temporal (phenological) and spatial (distributional) mismatches wi severe demographic consequences for the species involved. *A. mellifera* has show great adaptive capacity, as it is found almost everywhere and in highly diverse climat and able to use its genetic variability (Cornuet and Louveaux 1981) to adapt to clima change. In contrast, the Asian species have remained in Asia, which may reflect les adaptability to varied environments and fragility in the face of climate change.

Table 29.6: Decline of Honeybee's Population and Global Scenario (Gallai *et al.*, 2009)

Country	Decline (Per cent)	Duration
Netherland	58-65	Last 25 yrs
UK	61	Last 10 yrs
Germany	57	Last 18 yrs
Brazil	>53	Last 15 yrs
USA	>50	Last 20 yrs
China	>50	Last 20 yrs
India	>40	Last 25 yrs
Poland	>35	Last 15 yrs

Among different reasons for bee decline are habitat loss and fragmentatio chemical intensive agriculture, invasive species and climate change (Potts *et al.*, 2010 Climate change is thought to be one of major threats to pollination services (Heglan *et al.*, 2009; Schweiger *et al.*, 2010). Climate change could alter the relationships betwee flowers and pollinators, and pollinators will need to be protected to ensure that the continue their pollination function, which is required for the economy and for th ecological wellbeing. The pollination crisis that is evident in declines of honeybe and native bees worldwide is due to disruption of critical balance between the tw mutually interacting organisms. Anthropogenic activity cause climate change

widely expected to drive species extinct by hampering individual reproduction and survival, by reducing the amount and accessibility of suitable habitat, or by eliminating other organisms. Changes in habitats and climates have resulted in substantial reductions in biodiversity and evidence has been accumulating that insect biodiversity is at risk as well (Abrol 2009).

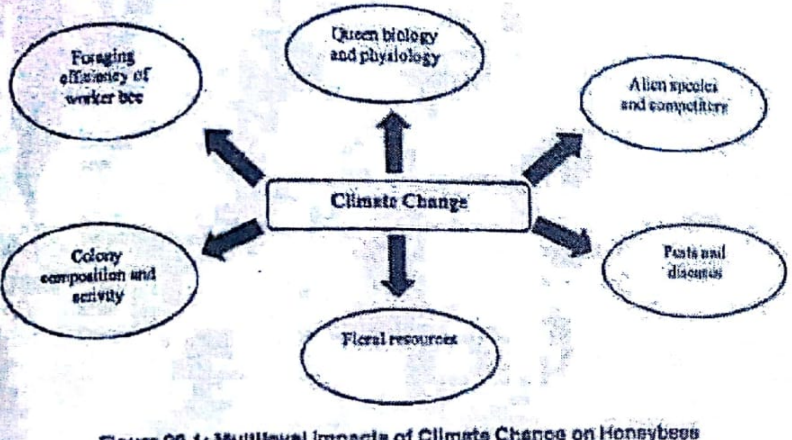

Figure 29.1: Multilevel Impacts of Climate Change on Honeybees (Reddy *et al.*, 2012).

Climate change can alter the quality of the floral environment and increase or reduce colony harvesting capacity and development (LeConte and Navajas 2008) and can influence the development cycle. However, rise in temperature is thought to be the most important effect of climate change with respect to plant-pollinator interactions (Kjohl *et al.*, 2011). The possible responses of species to climate change are adaptation to the new environment, migration and extinction. The first response is unlikely since expected climate change occurs too rapidly for populations to adapt by genetic change. With increase in temperatures many species move towards poles and higher altitudes. Tropical pollinators may respond to different temperature cues than pollinator species at higher latitudes (Coope 1995). The effect of climate change on insects depends upon their thermal tolerance and plasticity to temperature changes. Climate change has also changed some of the migration patterns seen in honey bees. The Himalayan cliff honey bee, which is known to dwell at about 3,100 meters, has started ascending farther up the mountains to about 3,500 meters to escape the weather (Pokharel 2014).

Impact of Cell Phone Radiations on Honeybees

The cell phone is an important innovation which has greatly influenced the people lifestyle. Several studies revealed that the cell phone radiations influence human physiological processes and have a considerable effect on other life forms. The effects radiations are being felt by wildlife and the environment as whole, bees,

birds, worms, trees are being affected. Kumar *et al.* (2011) studied the influence of cell phone radiations on the biochemical aspects of drone of *Apis mellifera* L. and reported that the concentration of various bio-molecules increased under the influence of electromagnetic radiations. Similarly, Sivares (1981) observed eye mutation in honey bee influenced by electromagnetic radiations. Greenberg *et al.* (1981) reported that in the exposed colony there was increased hive temperature, abnormal propolization, impaired hive weight gain, queen loss and decreased sealed brood and poor winter survival. The queen produced drones with abnormal wings, antenna and legs under the influence of cell phone radiations (Branden and Frisch 1986). Because of this reason and consequences, the bees have been frequently used as bio-indicators of electro pollution. Sainudeen (2011) reported a great alteration in colony status of honeybees exposed to mobile phones. The exposed colony showed loss in returning ability, bee strength and fecundity etc.

Effect of Pesticides on Bee Fauna

In the global scenario the populations of honey bees have been declining. Recently there is a growing pesticides grievance on honeybee population and dynamics along with their products reduced with considerable economic impacts on beekeepers. Abiotic stress from the lethal effects of pesticides is currently being scrutinized as a contributing factor to poorly understood bee colony losses. Pesticides are a class of chemicals or biological agent with properties designed to deter, kill, incapacitate, or otherwise limit damage by pests (Markin and Bethany 2011). The growing consensus that pesticides has killed honeybees and their food sources and resulted in bee death and their products declines. However, the database on the side effects of pesticide under local circumstances are little and incomplete (Keralem *et al.*, 2009; Maria and Tariku 2014), and remaining obscure.

Colonies of honey bees often are exposed to pesticides when foragers gather contaminated nectar and pollen in the field, and return with it to the hive where it is stored and shared among nest mates. Colony losses from lethal exposure to insecticide are easy to diagnose because a large number of dead bees usually are found on the bottom or near the entrance of the hive. However, sub lethal exposures might have delayed and extended effects on colony growth and survival. Pesticides also can affect immunity and make colonies more vulnerable to loss from disease-causing agents (James and Xu 2012). Colony losses are attributed to a myriad of causes including exposure to pesticides. Honey bees are highly sensitive to pesticides because they have relatively few genes encoding detoxification enzymes e.g. cytochrome P450 monooxygenases (P450s), glutathione-S-transferases, and carboxylesterases (HGSC 2006; Claudianos *et al.*, 2006). Recent studies showed an association between spore numbers of the intracellular microsporidian parasite *Nosema Apis* and *N. ceranae* in worker bees and pesticide exposure (Alaux *et al.*, 2010; Pettis *et al.*, 2012; Wu *et al.* 2012).

Pesticides kill by direct contact, stomach poisoning or fumigation. There are eight main types of pesticides. The most dangerous pesticides for bees are among the insecticides, but some of the other pesticides harm them too. Most insecticides are dangerous for people as well as bees. Now it's time to develop appropriate steps and

implement effective development and extension strategies to minimize and/or control the negative impacts of accidentally using pesticides (Benga, 2014).

Table 20.7: Toxicity of Insecticides against Honey Bees

Description of Insecticides/Chemicals	Author
BHC was a powerful contact and stomach poison for honey bees	Way and Sings (1948)
DDT was moderately toxic to bees, while sulphur and toxaphene were slightly toxic	Anderson and Atkins (1958)
Permethrin was highly toxic to bees after 48 hrs of exposure	James *et al.* (1980)
Phosphamidon was highly toxic to bees whereas neem oil was less toxic	Panda *et al.*, 1980
Endosulfan was found the least toxic and cypermethrin was most toxic for *A. cerana*	Singh *et al.* (1997)
Cypermethrin was highly toxic, while neem oil and ethofenprox was less toxic	Gour and Pareek (2005)
Profenoprox and indoxacarb were highly toxic and endosulfan was less toxic after 24 hrs of treatment against bees	Pastagia and Patel (2007)
Carbosulfan was highly toxic, while methiocarb and carbaryl were comparatively less toxic	Aken *et al.* (2000)
Malathion was highly toxic whereas ceftamethrin was less toxic	Sharma and Abrol (2005)
Phosphamidon, ethofenprox and fenvalerate were highly toxic after 6, 12 and 24 of treatment/exposure, respectively	Painkra (2014); Painkra *et al.* (2015)

Future Challenges and Marketing Strategies

It is estimated that the population of India will be about 140 crores by 2030. India will have to face two formidable challenges from coming decade *i.e.* to provide employment to large number of youths and enough and nutritive food to all people. According to the agricultural scientists, India needs minimum 75 lakh bee colonies just to pollinate and increase productivity of 12 major crops which are self-sterile and need insect pollination. Beekeeping industry can play its own humble role in addressing both these challenges.

Marketing facility is an important factor for beekeeping industry for its growth and development. Without proper marketing, the bee keeping industry cannot flourish well. The honey collected from many producers is often of poor quality and fails to meet the regional and global standards. In the export markets, there is great competition and the countries importing Indian honey have their own quality requirements regarding colour, aroma, constituency and floral sources. Most of the beekeepers are unaware of these standards. Therefore, it is necessary to educate the beekeepers with better apiary management and about proper honey sustaining and processing techniques to improve quality of the products for national and international markets. Therefore, it is required to standardize methods of hygienic collection of honey and other hive products for export that will augment the income of the beekeepers manifold.

Suggestions/Recommendations

- Beekeeping from many viewpoints *viz.* employment generation among rural youths and tribal population, producing valuable products and above all increasing the yields qualitatively and quantitatively of various agricultural and horticultural crops, apiculture has to be developed on priority basis.
- Apiculture and agriculture are interdependent and cannot develop in isolation. Integration between apiculture and agriculture is therefore essential for mutual benefits and development.
- Mitigating damage of pesticide use to honeybees is the responsibility of all parties involved and requires concerted effort to minimize the risk, which is aimed at minimizing the ill effects of pesticides on honeybees and their products.
- Development of productive bee strains through selective breeding and conservation of bee genetic resources for multiple economic benefits. Preparation of extensive floral calendars for different ecological zones and mass multiplication and planting of suitable bee flora through various forestry schemes (ex. Agro-forestry, farm forestry, social forestry etc.).
- The policy makers, forest managers and the local community to be trained on the importance of bees and their mutual relationship with plants. Further research in pollination biology of wild plants and agricultural crops especially rare plants given priority. Although we get a substantial amount of honey from *Apis dorsata* (wild bee), proper beekeeping demands, systematic utilization of resources through domesticated bees is essential.

Conclusion

Apiculture benefited the society by producing tangible products and by pollination services which ultimately increases the production and creating ecological balance. Honeybees provide honey and other hive products like royal jelly, bee venom, bee pollen and propolis, which have great economic value. To increase the profits from the apiary units, the beekeepers are required to exploit bees for the productions of these hive products. Apiculture is one of the most widely spread agricultural sub-sectors making substantial contribution to household livelihoods and food security. There is a great prospect of beekeeping in India on the basis of the socio-economic context of the country and some special features of the enterprise. India is abundant in nectar and pollen resources and the awareness to maintain the existing bee flora and multiplication of plant species is important for its sustainability. It will be a great source of employment creation for the rural people to reduce the poverty. Beekeeping does not compete with other enterprises for resources sharing as the bees use nectar and pollen grains of plants. Marketing facilities, capacity building of bee keepers, skilled trainers, dissemination of new research information, timely loan facilities, least use of pesticides, development of floral calendar, availability and/or facilitate suitable bee flora by agroforestry, farm forestry, social forestry etc. are key activities for development of apiculture.

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